Application of PCT to the EBR II Ceramic Waste Form

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INTRODUCTION

We are evaluating the use of the Product Consistency Test (PCT) developed to monitor the consistency of borosilicate glass waste forms for application to the multiphase ceramic waste form (CWF) that will be used to immobilize waste salts generated during the electrometallurgical conditioning of spent sodium-bonded nuclear fuel from the Experimental Breeder Reactor No. 2 (EBR II). The CWF is a multiphase waste form comprised of about 70% sodalite, 25% borosilicate glass binder, and small amounts of halite and oxide inclusions. It must be qualified for disposal as a non-standard high-level waste (HLW) form. One of the requirements in the DOE Waste Acceptance System Requirements Document (WASRD) for HLW waste forms is that the consistency of the waste forms be monitored.[1] Use of the PCT is being considered for the CWF because of the similarities of the dissolution behaviors of both the sodalite and glass binder phases in the CWF to borosilicate HLW glasses. This paper provides (1) a summary of the approach taken in selecting a consistency test for CWF production and (2) results of tests conducted to measure the precision and sensitivity of the PCT conducted with simulated CWF.

EXPERIMENTAL

Several series of tests and analyses were conducted to evaluate the applicability of the PCT to the CWF for the purposes of product consistency. The key issues considered include the following:

- *Is the –100 +200 mesh fraction of crushed CWF used in the PCT representative of the bulk waste form?*

This issue was addressed by comparing (1) the microstructure of the crushed CWF with that of the bulk material and (2) the gross compositions of various size fractions of crushed CWF.

- *Is the PCT response sensitive to possible processing upsets and compositional variations?*

This issue was addressed by comparing PCT responses in tests conducted with CWF made with different compositions and processing conditions and with replicate CWF made with the same composition and processing conditions.

- *Can the PCT be conducted with the same precision using CWF as tests with borosilicate glass?*

This issue was addressed by conducting replicate tests and an interlaboratory study.

- *Can the PCT be conducted with CWF in a hot cell?*

This issue was addressed by comparing the precision of tests conducted with radioactive CWF in a hot cell with that of tests conducted on the benchtop with non-radioactive CWF.

- *Does a comparison of the PCT response of CWF with that of the Environmental Assessment (EA) glass provide evidence of adequate chemical durability?*

This issue was addressed by comparing 7-day PCT results with CWF and EA glass and considering the results of a long-term PCT conducted with CWF.

RESULTS

Due to the word limits of this summary, only the results of the interlaboratory study are discussed here. In applying the PCT to the CWF, use is made of an optional step in the PCT procedure, namely, analysis of the water wash solution used to remove fines from the crushed material, if the presence of soluble inclusion phases is expected or suspected. This step is not used in the PCT conducted with most borosilicate glasses, but is used for the PCT conducted with CWF because of the known presence of halite inclusions. Therefore, in the PCT conducted with CWF, the crushed CWF is first washed with absolute ethanol to remove fines (halite is essentially insoluble in ethanol) and then washed with demineralized water. The water wash solution is analyzed for Cl (and sometimes Na) to monitor the amount of halite in the CWF. The washed CWF is then subjected to the standard PCT. As in the case with HLW glasses, the PCT solution is analyzed for B, Li, Na, and Si as a measure of the chemical durability. In the case of the CWF, these elements are released due to dissolution of both the sodalite (Li, Na, and Si) and binder glass (B, Li, Na, and Si) phases. The fact that B is present only in the binder glass is used to distinguish between the dissolution of sodalite and binder glass.

Table 1 shows the results for Cl and Na in the water wash solution and B, Na, and Si in the PCT solution for tests with CWF and B, Na, and Si in PCT conducted in an inter-laboratory study with LRM glass, which is a standard borosilicate glass.[2] The results in the table are the mean plus or minus one standard deviation for triplicate tests conducted with CWF by 6 participants and LRM glass by 8 participants. The precision of the PCT, as measured by the standard deviation of the mean values of the participants, is the same for the tests with CWF and LRM glass.

Table 1. Results of PCT Conducted with CWF and LRM Glass

	Water Wash Solution, mg/L		PCT Solution, mg/L		
	Na	Cl	B	Na	Si
CWF	160 ± 11	240 ± 16	2.5 ± 0.5	31 ± 6	33 ± 6
LRM glass	---	---	27 ± 3	160 ± 12	82 ± 5

CONCLUSIONS

The PCT is appropriate for monitoring the consistency of CWF. The PCT response is sensitive to the composition of the CWF and to possible processing upsets. The precision with which the PCT can be conducted with CWF is similar to that for the PCT with borosilicate glass waste forms. Comparison of the PCT response with CWF to that with EA glass indicates that the

chemical durability of the CWF meets the EA benchmark. The PCT can be used to meet the WASRD requirement for product consistency in qualification of the CWF for disposal.

REFERENCES

1. *Waste Acceptance System Requirements Document, Rev. 03*, U.S. Department of Energy, Office of Civilian Radioactive Waste Management report DOE/RW-0351, April 1999.
2. W. L. Ebert and S. F. Wolf, "An Interlaboratory Study of a Standard Glass for Acceptance Testing of Low-Activity Waste Glass," J. Nucl. Mat. 282, 112-124 (2000).

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